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FURTHER NOTES ON THE STUDY OF THE HUMAN LUNG DISTOME, *PARAGONIMUS WESTERMANI*

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I. CERCARIA FOUND IN FRESHWATER SNAIL

Since 1915, when I first discovered seventeen species of cercariae infesting the mollusks found in the rivers in Shinchiku Prefecture, Formosa, I have attempted to infest with the miracidia of the human lung distome the river snails, in which the miracidia of other species can develop into cercariae, and thus to learn the complete life cycle of the parasite in question. I thought that one of the seventeen different forms of the cercariae I examined belonged to that of the human lung distome for the following reasons:

(a) This is the only form found in the aboriginal villages, where human lung distomiasis is most prevalent.

(b) Both the miracidia of the human lung distome and this species of cercaria prefer a particular water snail to others as hosts.

(c) Similarity in shape of the spine in the oral sucker and of the excretory vesicle of both the encysted larvae of the human lung distome in the crab and this species of cercariae.

To prove the above conjecture a great many devices were tried, but all turned out to be futile, due probably to the lack of good tap water. It was very difficult to keep the water-snail alive in the aquarium long enough to finish the infection experiments. Finally a live box was made and immersed in the river. In this box both the water snails having the supposed cercariae of the human lung distome and the crabs free from previous infection were put together. This experiment also failed. But I found in the crabs the youngest encysted larvae that seems to have just entered. They were supposed to be those of the human lung distomes, since similar larvae have been reported from Japan proper—Niigata, Gifu, Okayama and Tokushima prefectures. So I reported elsewhere the encysted larvae I found were those of the human lung distome.

In the spring of 1917, Dr. Yokokawa and myself discovered a new species of the encysted larvae infesting the crabs found in the infected regions of Shinchiku Prefecture in Formosa. They were identified to be those of *Stephanolecithus parvus* n.g., n.sp., that is a species independent of the human lung distome. It may be objected that there may be more than one species of cercariae infesting the water snails found in Japan proper, and mine may not actually be those

of the human lung distome. To meet this objection investigation was resumed in October, 1917, at Kalapai. To my great astonishment, there I could find four different species of cercariae. No. 12* (80.0 per cent), No. 15 (13.3 per cent.), No. 4 (3.3 per cent.), and the newly discovered one (16.6 per cent.). Besides, I came across two forms of redia, of unknown species. Usually only one species of cercaria is found in the water snails, but there are also many cases in which more than one species of the cercariae are found in one individual. This newly discovered cercaria seemed more closely related with that of the human lung distome than No. 12 does.

The cercaria No. 12 was discovered by myself in January of 1918, widely distributed in the water snails found in the rivers running through the villages free from infection, such as Ako, Tainan, Kagi and Nanto. This makes their identity to the human lung distome extremely doubtful. The newly discovered cercaria will therefore be described in some detail.

This cercaria was discovered in May, 1917, by myself in *Melania libertina* G. found in the rivulet in Torunsho in Shinchiku Province, and in December of the same year, in the same species of the water snail in Kalapai. It is oblong, 0.2 to 0.25 mm. long by 0.08 to 0.1 mm. wide. The oral sucker is large, its diameter being 0.06 mm. It is provided with a sharp spine. The abdominal sucker is smaller than the oral and has the diameter of 0.04 mm. Around the sucker is a group of glandular cells; the glandular ducts run toward the anterior end of the body with a wavy course. The excretory vesicle is a straight tube appearing like a slit and lies on the median line arising very closely to the abdominal sucker and running toward the posterior end of the body. The tail is very small, having the length of 0.02 to 0.03 mm. and the breadth of 0.01 to 0.015 mm. At the posterior end of the tail are several short spines arranged in a row. The cercaria moves fairly lively.

The redia which gives rise to the cercaria was also found. Young rediae are spheroidal, 0.1 to 0.2 mm. in diameter, or spindle shaped, 0.2 mm. long by 0.1 mm. wide. The full grown rediae may either be spindle shaped or cylindrical, with the length of 0.3 to 0.7 mm. by the width of 0.15 to 0.3 mm. They have a pharynx 0.1 mm. in diameter and a voluminous intestine, which reaches as far as the posterior margin of the body. In the intestine is found a brownish or variegated mass.

Morphologically this species is more closely related to the young encysted larva of the human lung distome found in the crab than

*The cercariae which came to my observation have been provisionally called by numbers.

No. 12, which has been reported as the cercaria of the human lung distome in the Journal of Experimental Medicine, vol. 26, No. 3. This new discovery has already been reported in Japanese in the Tokyo-Iji-Shinshi, February, 1918.

Since that date, various workers published their views regarding this species of cercaria. Kobayashi reported in Japanese the results of his study on the cercaria of the human lung distome carried out in Corea in the Chosen (Corean) Igakkai Zasshi No. 21. He thinks that the cercaria A, as he names it, which is found in *Melania gottschei* M., *Melania nodiperdo* var, *quinaria* M. and *Melania extensa* (?) M., is the cercaria of the human lung distome. It seems very likely that this species of cercaria is identical with mine. Besides, Miyairi, who is studying the first intermediate host of the human lung distome, holds

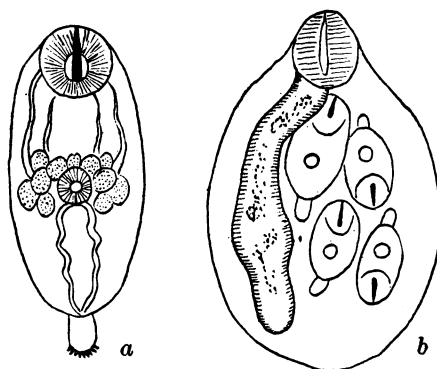


Fig. 1.—Human lung distome; a, cercaria, $\times 160$; b, redia, $\times 80$.

the view that this species, which is found in *Melania pannicicincta* M. and *Melania extensa* M., must belong to the cercaria of the human lung distome. It was reported also in Japanese by him in the "Ikaijiho," No. 1252, that he had succeeded in obtaining this species experimentally by infecting the water snails with the miracidium of the human lung distome.

Yoshida's cercaria H seems to belong to this species. He states that his cercaria H is provided with the pharynx being situated just in the middle or a little anterior to the middle part of the oral and the abdominal suckers, but in our cercaria it is lacking. Neither are the spines found at the end of the tail. These differences may be due to a difference of observation. Yoshida, however, does not attempt to institute any relation of this species to the cercaria of the human lung distome (Osaka Igakkai Zasshi vol. 16, No. 3).

II. YOUNG ENCYSTED LARVAE FOUND IN THE CRAB

The young encysted larvae in the crab hitherto supposed to be those of the human lung distome as reported in my former communication in the *Journal of Experimental Medicine*, vol. 26, No. 3, was since identified by Dr. Yokokawa and myself to belong to an undescribed species of parasite, *Stephanolecithus parvus*. Ever since, I have carried out investigation directed toward the discovery of those of the human lung distome in the crab, and I think I have succeeded in doing this.

This form is chiefly found wedged in the muscular tissues or in the epidermis of the crab. Its shape and size vary according to the ages of the worm.

The youngest specimens move freely through the tissues of the host, showing a squirming motion in a thin cyst wall. The cyst is very

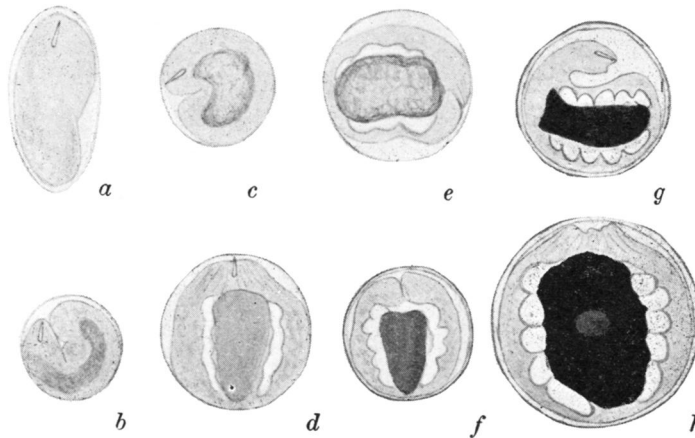


Fig. 2.—Encysted larvae; *a*, youngest found, $\times 120$; *b-c*, successive stages, $\times 80$; *f*, nearly full grown, $\times 80$; *g-h*, full grown, $\times 80$.

pliable and changes its shape according to the worm inside. The stretched specimen together with the cyst measures 0.18 to 0.26 mm in length by 0.11 to 0.1 mm. in breadth. The oral sucker is provided with a sharp spine. The abdominal sucker is smaller than the oral. It lies a little anterior to the middle part of the body. The excretory vesicle is slit-like, being situated on the median line arising from the dorsal side of the abdominal sucker or sometimes beyond the sucker and reaches as far as the end of the tail. The intestine has not yet developed.

Some of the encysted larvae have a globular shape, 0.18 to 0.22 mm. in diameter. The larva lies in the thin wall of the cyst, folded on itself. The excretory vesicle is well developed. It reaches a little

anterior beyond the middle part of the body, and has a dark gray color. The suckers are just the same as those just described.

The large specimen has the diameter of 0.24 to 0.26 mm. The wall of the cyst is thin and pliable. The worm lies folded on itself or sometimes straight. The excretory vesicle is very large, and has the content consisting of coarse granules of a gray color. The excretory vesicle is especially thickly provided with pigment. A slender, long and winding intestine lies laterally along the excretory vesicle. It is somewhat difficult to detect it. The encysted larvae are sometimes oblong in shape. The cyst wall is so thin that slight pressure breaks it, liberating the worm.

The young distome just out of the cyst has a leaf-like form 0.3 mm. long by 0.15 mm. wide. The oral sucker has the diameter of 0.04 mm., and is provided with one spine. The pharynx is well developed. The esophagus is short. The intestine is slender and takes a slightly winding course laterally to the excretory vesicle. The abdominal sucker is smaller than the oral, and measures 0.035 mm. in diameter. It is situated a little anterior to the middle part of the body. The surface of the worm is covered with short, weak spines.

The encysted larvae are found both in the muscular tissues and the epidermis of the crab. Usually we come across very few of them. The reason for this is probably that the encysted larvae of this species are not conspicuous and are likely to be overlooked, being taken for the section of the muscular tissues or deposition of the cuticular pigment. The thinness of the wall of the cyst may make its detection very difficult. In one of the crabs kept for two weeks in confinement I found a very large number of the fairly well developed encysted larvae. Outside the muscle and the epidermis, they were also found in the liver, where their detection is most difficult. They have not yet been discovered in the gills.

This species of the encysted larvae appears very different from the full grown encysted larva of the human lung distome, but close examination will reveal that they decidedly show characteristic developmental stages of the human lung distome. I do not hesitate to state that its identity with the larvae of *Paragonimus westermani* is a matter beyond dispute.